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The series Fishery Facts documents developments in research in the fishery sciences, including biology, technology, and engineering. The publications are written by scientists and other staff members of the National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

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FISHERY FACTS-6

alaska's fishery resources - - -

the dungeness crab

DAVID T. HOOPES

NMFS Extension Publication

SEATTLE, WA
NOVEMBER 1973

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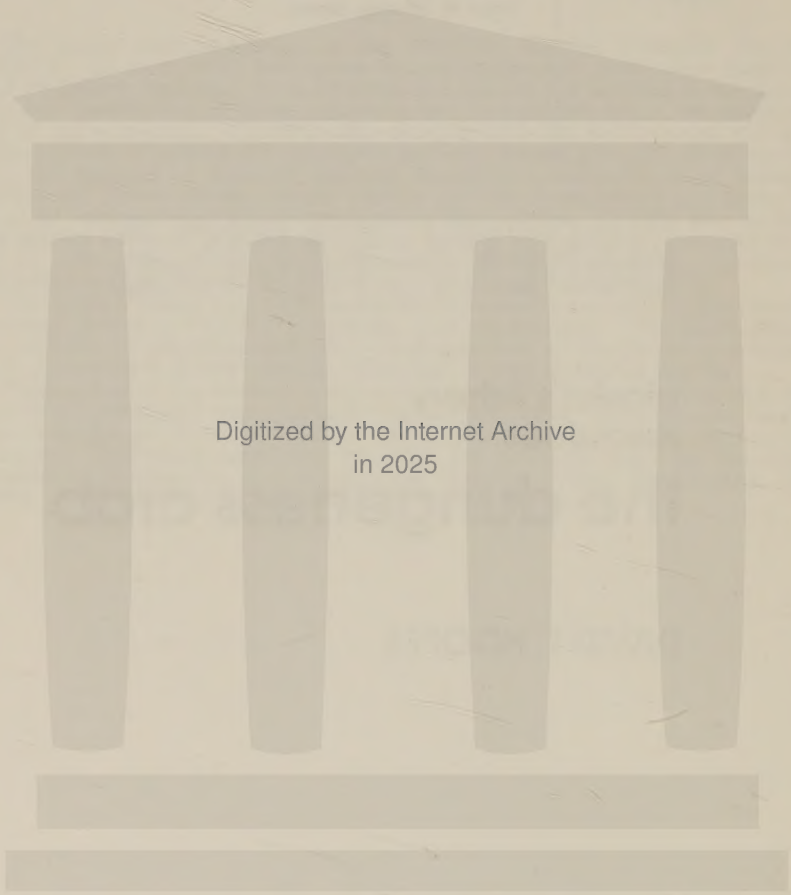

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ABSTRACT

Dungeness crabs, *Cancer magister*, occur in the inshore waters of the west coast of the United States and Alaska. Alaska production has averaged 9.2 million pounds annually since 1960; the yearly average value to the fishermen was between $1 and $2 million. A female may lay up to 1.5 million eggs, which adhere to small appendages under her abdomen until they hatch 7 to 10 mo later. After hatching, the minute larvae spend 3 to 4 mo in the water column as plankton. At the end of their planktonic development period, the larvae settle to the bottom and transform into juvenile crabs. Dungeness crabs grow only during the molting period. Males may live for 8 yr and attain 10 inches in width; females are considerably smaller. The commercial fishery takes only male crabs, which are caught in baited pots. Crabs are either delivered to market alive or are cooked and prepared in several ways. In Alaska the State Department of Fish and Game is responsible for conducting research required for rational management and protection of this valuable shellfish resource.

ALASKA'S FISHERY RESOURCES —THE DUNGENESS CRAB

DAVID T. HOOPES[1]

INTRODUCTION

The Dungeness crab, *Cancer magister,* supports one of Alaska's important commercial fisheries, a fishery that shows signs of further increase as the marketing of fresh Alaska Dungeness crabs in the contiguous United States and Hawaii continues to develop. Fishermen began harvesting Dungeness crabs in Alaska in 1913, but the market remained relatively poor until the late 1950's when the Dungeness crab fishery in the Pacific coast states of Washington, Oregon, and California temporarily declined. This decline, coupled with increased consumer demand, resulted in more favorable marketing conditions for Alaskan crabs; and the annual landings of Dungeness crabs in Alaska have averaged 9.2 million pounds since 1960, as compared with only 3.2 million pounds in the 1950's. At current prices, fishermen receive between $1 and $2 million annually from the commercial fishery (Figure 1).

In addition to the commercial fishery, many Dungeness crabs end up on Alaska dinner tables via a well-established personal-use fishery.

BIOLOGY

Dungeness crabs, the only species of the genus *Cancer* currently of commercial importance in Alaska, occur from Amchitka in the Aleutian Islands to Magdalena Bay in Baja California. They inhabit bays, estuaries, and the open ocean near the coast from the intertidal zone

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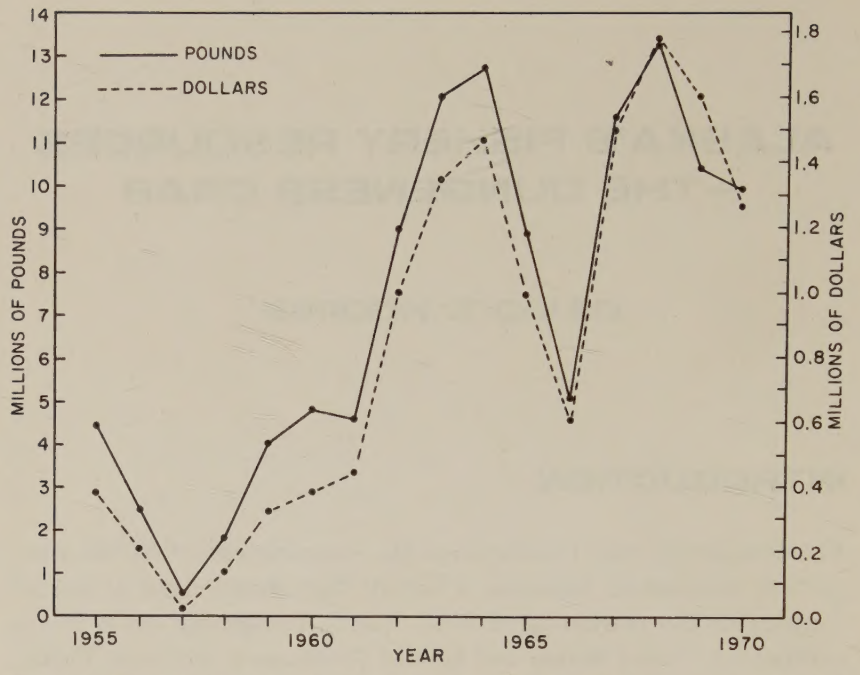

Figure 1.—Pounds landed and value to the fishermen for Dungeness crabs landed in Alaska, 1955-70.

to depths greater than 50 fm. They may be found on almost any substrate but are most abundant on sand or sand-mud bottoms. Crabs from the open ocean are usually larger than those from bays and estuaries.

Dungeness crabs belong to a group known as the brachyuran or true crabs. Crabs in this group can be distinguished from the other large group found in Alaska, the anomurans (king crabs, hermit crabs, etc.), by their four distinct pairs of walking legs (not including the chelipeds, or pincer legs); in the anomurans the legs of the fourth pair are indistinct because they are small and turned upward or are covered by the top shell (carapace). Another way to distinguish between the two groups is that the abdomen, or flap, of a brachyuran crab is symmetrical, usually hard, quite small, and tightly flexed beneath the main body of the crab, whereas the abdomen of an anomuran crab is asymmetrical, sometimes soft, proportionally larger, and often not flexed, as in the hermit crabs.

All species of the genus *Cancer* have a broadly oval carapace with several toothlike projections on each side beginning with the lateral edge of the eye notch, but the Dungeness is the only species in which

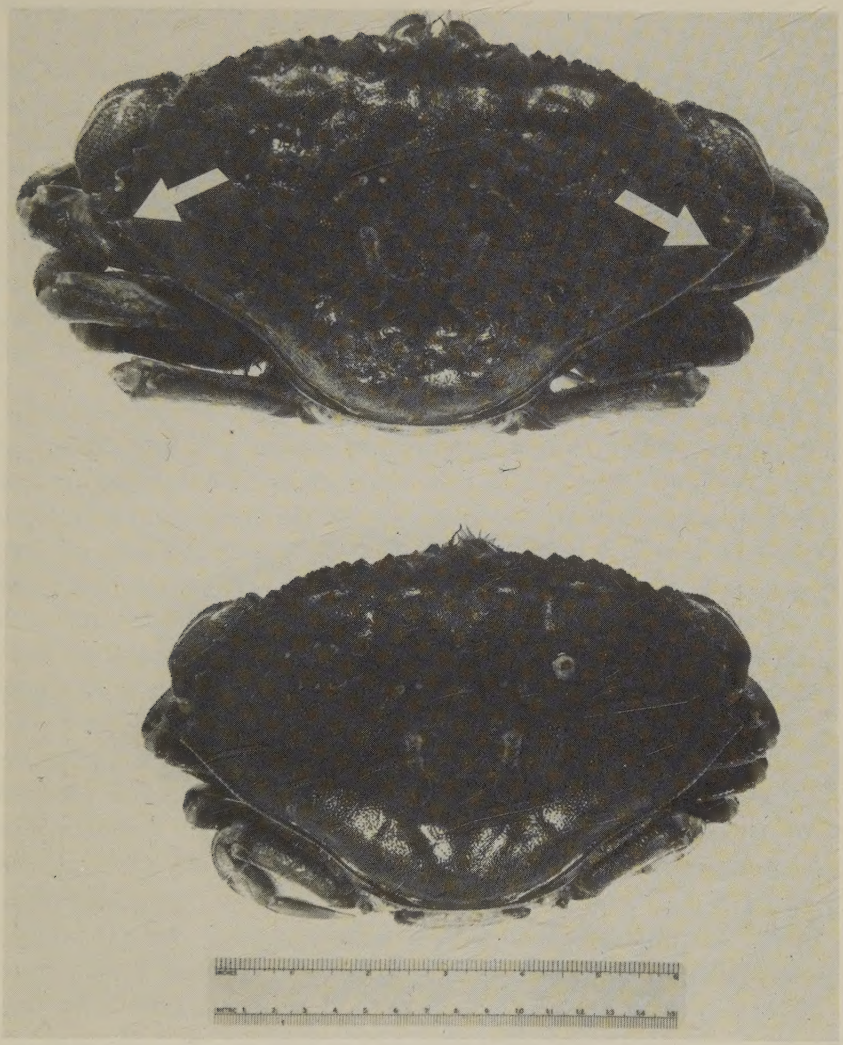

Figure 2.—Dorsal view of male (top) and female (bottom) Dungeness crabs. Note the notch immediately in front of the 10th spine (arrows) on each side of the male carapace where the legal width measurement is determined.

the widest point of the body coincides with the tenth projection (Figure 2).

An accurate and easy way to determine the sex of a Dungeness crab is by the shape and size of the abdomen: the abdomen of the female (Figure 3, bottom), which is about 1½ times as long as it is wide, has a considerably broader base and rounder margin than that

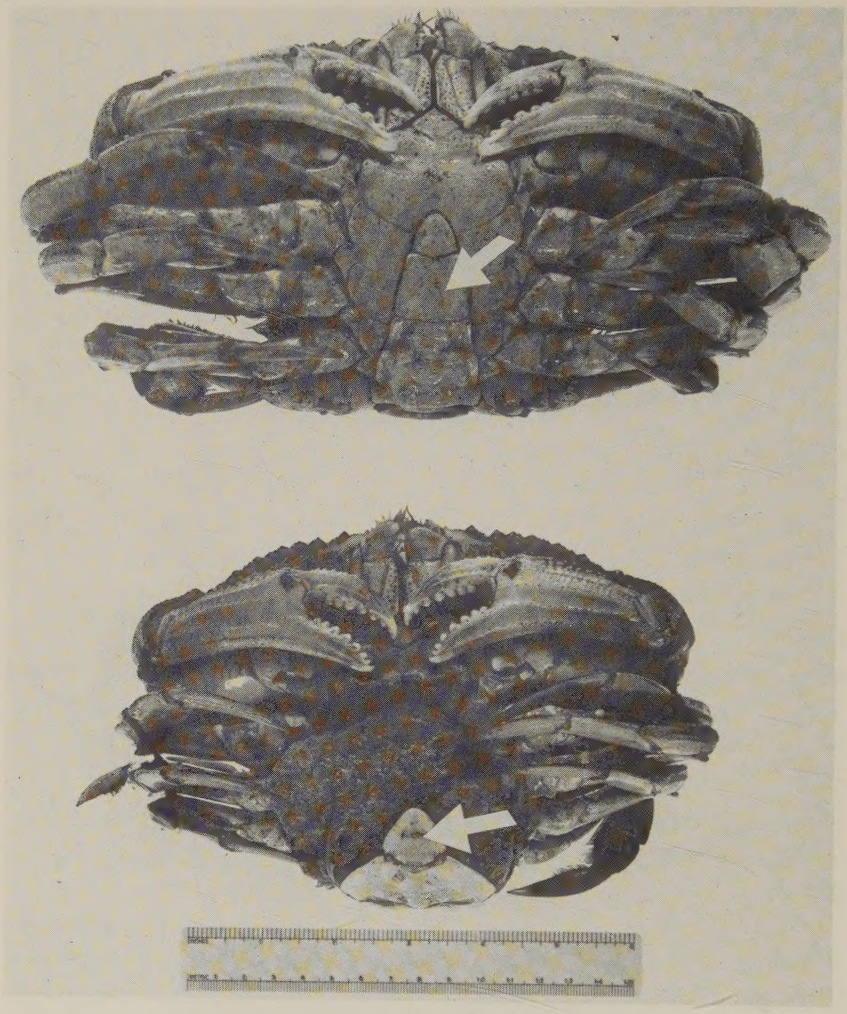

Figure 3.—Abdominal view of male (top) and female (bottom) Dungeness crabs. Note the narrow elongate abdomen on the male (arrow) and the broader shorter abdomen on the female, under which is attached the egg mass.

of the male (Figure 3, top), which is generally twice as long as it is wide. Female Dungeness crabs do not grow as large as males. A criterion often used by fishermen to determine the sex of adult crabs is that the arch of the carapace from front to back is markedly greater in the female than the male; i.e., the female shell is more domelike than the male (Figure 2).

Reproduction

Our knowledge of the reproductive biology of the Dungeness crab stems primarily from the excellent studies by a Canadian biologist, T. H. Butler. After working intensively with natural populations for several years, Butler (1960) concluded that males are polygamous (each male may mate with more than one female)—a behavioral characteristic that could be important in maintaining reproduction of this species because the fishery harvests only male crabs. Before Butler's studies, polygamous behavior had been observed only for crabs kept in laboratory aquaria (Cleaver, 1949).

Mating occurs when the adult crabs move into shallow waters in the spring, and it is closely tied to the female's molting cycle. A few days before the female is ready to molt, the male, who does not molt at this time, clasps her in an abdomen-to-abdomen embrace and holds her this way for several days. If the female becomes restless, the male grasps her more firmly with his walking legs and strokes her carapace with his chelae (pincers), which seems to pacify her. When the female is ready to molt, she touches her partner's eyestalks repeatedly with her chelae and is permitted to change her position so as to be right side up and face to face with her mate, who may assist her in the molting process. When the female's molting is complete, the male pushes the castoff shell away but continues to grasp the female and turns her back to the mating position—abdomen to abdomen with the male above. The male then transfers sperm to receptacles lying underneath the female's abdominal flap. Transfer of sperm can take place only after the female has molted and before her new shell hardens. Biologists are not certain how male crabs know when females are ready to molt, but because molting is probably controlled by hormones, it seems reasonable to assume that some hormone released into the water prior to molting alerts the male to the presence of a receptive female.

The eggs are laid in the fall several months after the mating season. The sperm have remained in the receptacles and now fertilize eggs as they leave the oviducts on their way to the female's abdomen. The eggs are carried under the abdomen, where each one is attached by a tiny filament to appendages called pleopods. The number of eggs deposited by a female is related to her size—the larger the female, the greater the number of eggs deposited. As many as 1.5 million eggs have been found on a single female. The eggs are bright orange when first laid but become progressively darker until just

before hatching, when they are brown or black. They hatch into free-swimming larvae during the spring after having been carried by the female for 7 to 10 mo.

When first hatched, the larva of a Dungeness crab is of the form known as a zoea; this later changes to a form called a megalops (Figure 4). The zoea is about 1/16 inch long and does not at all resemble the adult crab; its carapace has three spines and a long process at the front of the head called a rostrum. The zoea retains this form as it progresses by a series of molts through five stages, although at each successive stage it is larger and more developed than in the previous stage (Poole, 1964). The five stages are completed in 3 or 4 mo, after which the zoea transforms into the second type of larva—the megalops. During the single megalopic stage, the larva is about 1/2 inch long and resembles an adult crab more than it does a zoea (Figure 4). It has two pincers and four pairs of walking legs, but the abdomen, rather than being small and flexed as it is in the adult, is quite large and is held out behind the body. Up to this time the crab larva has lived as a member of the plankton community, which includes all plant and animal organisms that are carried about by the movements of the water. During the planktonic existence, the larva may

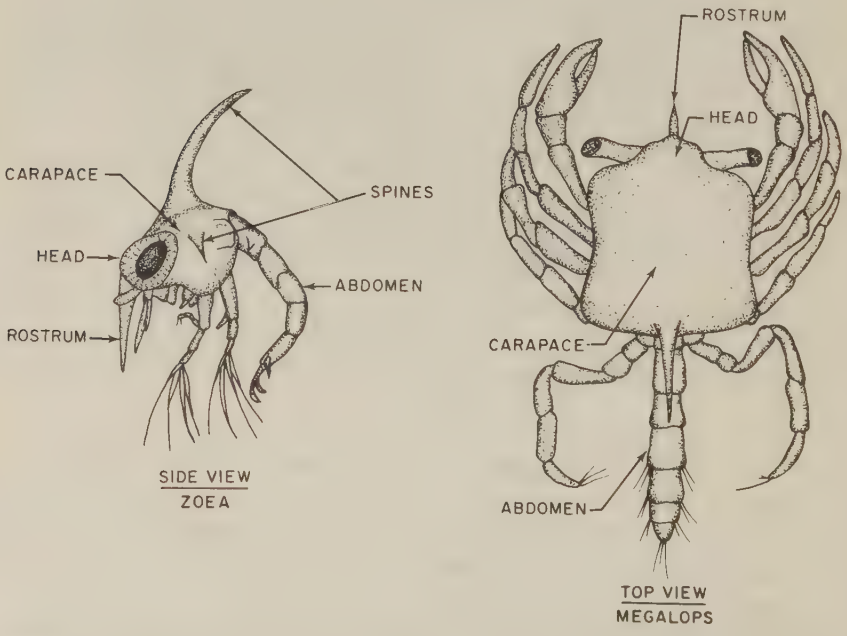

Figure 4.—Two stages (greatly enlarged) in the development of the Dungeness crab. The zoea is normally about 1/16 inch long and the megalops is about 1/2 inch (zoea after Mir, 1961; megalops after Poole, 1964).

be eaten by shrimps, herring, young salmon, or other larger organisms. Only a small percentage of the many Dungeness crab larvae produced each year survive the planktonic stage. Those that do, settle from the plankton when the megalopic stage is completed and begin life on the bottom.

The young crabs, now termed postlarvae or juveniles, are about 5 mo old. They are different from the megalops in that the abdomen is smaller and is tightly flexed beneath the body as it is in the adult. They inhabit sandy bottoms in shallow water and seek refuge from predators such as larger crabs, halibut, or other bottom-feeding organisms by hiding among the seaweeds.

The Molting Process

The Dungeness crab, like most crustaceans, goes through a complex physiological process each time it molts. First a new exoskeleton (shell) forms within the old one. When the crab is ready to molt, it absorbs large amounts of water in its body tissues which causes it to swell and split the old shell horizontally across the rear of the carapace. This process enables the crab to shed the entire exoskeleton, including the lining of the anterior part of the gut, the hard stomach parts that are used for grinding food, the thin transparent covering over the eyes and eyestalks, the gill membranes, and the skeletal rods that extend into the leg muscles and serve as structures for muscle attachment. The splitting and withdrawing usually require about half an hour, and during this time the crab's body tissues absorb more water so that the soft new shell is expanded to allow for growth. It takes 1 or 2 days for the new shell to harden, and the crab buries itself in the sand during this period. Crabs are not considered good eating for a month or so after they molt because the meat contains too much water.

Molted crab shells remain intact after they are shed. These shells may appear on the beaches in large numbers during the brief span of 1 or 2 mo when most crabs are molting, and people who find them often think they are dead crabs.

Growth

Dungeness crabs grow rapidly during many brief intervals rather than gradually throughout their life. All growth takes place during the 1- or 2-day period when the shell of the crab is soft from molting. During the first year of life a crab may molt as many as 6 times and

growth is rapid. Thereafter, until sexual maturity—2 yr for females and 3 yr for males—a Dungeness crab molts only once a year and growth is slowed considerably.

For the first 2 yr both sexes grow at the same rate, but after 2 yr the females begin to grow more slowly than the males. The crabs are about 1 inch in carapace width at the end of their first year and 4 inches at the end of their second. The slower growing females rarely if ever attain the legal minimum size of 6½ inches, but males attain a width of 6 inches after only 3 yr and are almost 7 inches after 4 yr. Butler (1961) reported 8 yr as the maximum life span for male Dungeness crabs. At this age, some males had a carapace width of more than 10 inches.

Food Habits

Dungeness crabs are carnivorous. Their diet consists mostly of crustaceans (shrimp, small crabs, barnacles, etc.), clams, mussels, and worms. Many of these organisms live partly or wholly buried in the sand, and Dungeness crabs often forage for them by probing into the sandy or mud bottoms with their chelipeds.

Predators

Dungeness crabs fall prey to several organisms. The larvae are eaten by plankton-feeding animals, and the postlarval, juvenile, and adult crabs by fish, especially by those species closely associated with the bottom such as halibut and dogfish. The octopus has long been known to relish Dungeness crabs. In fact, the den of an octopus is often obvious because of the crab shells scattered about its entrance.

Autotomy

Dungeness crabs have the ability to autotomize, i.e., to separate injured or caught limbs from their bodies. As a result, they are often seen with appendages missing or reduced in size. Like many crustaceans, Dungeness crabs regenerate or grow new appendages to replace missing ones, and small appendages indicate that limb regeneration is occurring. The crab must molt several times before the limb attains normal size, although regenerating limbs do grow faster than the rest of the body.

COMMERCIAL FISHERY

Only legal-sized hard-shelled male crabs may be taken by the commercial fishery in Alaska. When females, sublegal-sized males, or soft-shelled crabs are captured, they must be returned to the water immediately with a minimum of injury. The minimum legal size is based on the greatest width of the carapace (Figure 2). Currently the legal minimum width is 6½ inches in southeastern Alaska and 7 inches throughout the rest of the State. The fishing season is open throughout the year. To learn specific regulations governing Dungeness crab fishing in local areas, fishermen should consult a current edition of "Alaska Commercial Fishing Regulations" and "Alaska Sport Fishing Seasons and Bag Limits." Both documents are published annually, and copies may be obtained from the Alaska Department of Fish and Game, Subport Building, Juneau, AK 99801.

Landings of Dungeness crabs from Alaska waters totaled 9.7 million pounds in 1970 and were worth $1.26 million to the fishermen (Figure 1). Over half the production came from Kodiak Island.

Boats, Gear, and Fishing Methods

The discussion that follows on fishing boats and gear and the methods used applies principally to western Alaska and is taken largely from Meyer (1968). Generally, smaller boats are used in central and southeastern Alaska, but the fishing gear and methods are the same.

Boats from 50 to 100 ft long and carrying a crew of three men are common in the Alaska Dungeness crab fishery. The holds are fitted with tanks through which large pumps circulate seawater to ensure that crabs will be delivered alive to the processor. Power barges are now popular for crab fishing in western Alaska waters because they can hold more crabs, accommodate more fishing gear, and fish during worse weather than can the smaller converted seiners or trollers frequently used for crab fishing. Because of their large size (average about 90 ft long), it is profitable for barges to make runs to the crab grounds that might take as long as 24 or 36 hr. For example, in June 1967, in just five trips one barge landed more than 300,000 pounds of Dungeness crabs in Kodiak. This catch was greater than the combined catch of all other Dungeness crab boats fishing in the same area during the same time.

Fishermen use baited pots (traps) for catching Dungeness crabs. The pots are 42, 48, or 60 inches in diameter (Figure 5). The pot frames are made of ¾-inch round steel stock with two pieces of 1½-inch stock welded to the bottom for ballast. The round stock is wrapped with natural rubber strips cut from inner tubes, and the frame is then covered with stainless steel wire meshes woven in 2-inch squares. The rubber strips insulate the stainless steel meshes from the frame, thus reducing damage by electrolysis. Each pot has two 8- by 4-inch oval entrance tunnels fitted with triggers that close from the inside to prevent large crabs from escaping. A 4-inch-diameter ring that is welded to the side of the frame near the top of the pot allows sublegal-sized males and most females to escape. Crabs are removed and bait cans changed through a door on the top of the pot. The door is made of stainless steel rod ¼ or ⅜ inch in diameter covered with stainless steel mesh. It is hinged at each end and locked in the closed position with rubber straps and hooks.

Figure 5.—Dungeness crab pot 60 inches in diameter.

The pots are baited with razor clams, squid, or herring. The bait is kept frozen on board the boat and thawed just before use. Razor clams are crushed; small squid are used whole; and large squid and herring are chopped into pieces 1 to 2 inches long. The bait is held in half-pint glass containers with louvered caps or in stainless steel louvered cans 7 inches deep and 4 inches in diameter with hinged lids. The filled bait container is hung in the middle of each pot by two sets of stainless steel hooks and rubber straps.

A polypropylene or similar type line with a plastic foam buoy fastened to one end is attached to each pot. The length of the line depends on the depth to be fished, but it is usually 10 to 20 fm (1 fm = 6 ft). The buoy is about 18 inches long by 4 inches in diameter and is tapered at the bottom end to reduce chances of fouling by drifting kelp. The buoy and line are both dipped periodically in a chlorine solution to remove fouling organisms, primarily algae and hydrozoans. All buoys used by each fisherman must be identically marked with colors and design registered with the Alaska Department of Fish and Game.

Just before the pots are set, the skipper selects a course and sets the vessel's automatic pilot. The skipper maintains a fairly straight course during the setting of a string or series of pots so that they can be located and recovered in rough or foggy weather. As a further aid in recovery of the gear and to prevent missing a pot, a colored float is used to mark the first and last pot of each string. As the setting of the gear begins, the buoy and buoy line of the first pot are trailed behind the moving boat. At a signal from the skipper, the first pot is pushed overboard. The next pot and its buoy line are then carried to the rail and the procedure is repeated until the last pot of the string is set. Each string contains 30 to 60 pots, set at roughly equal intervals along the course set by the skipper. Each boat fishes several strings, usually set parallel to each other and approximately parallel to the shoreline in 5 to 20 fm.

In good weather an efficient crew of two deckhands can pick and reset 60 pots or more in an hour and over 300 pots in a 10-hr day. To attain such speed an assembly-line approach must be used to handle the gear. The boat is brought alongside the buoy to be retrieved. The buoy line is brought on board with a boat hook and is run through a hydraulic power block mounted on the end of a boom. The boom is lowered so that the line can be set in the block and then raised so that the pot can be swung aboard the boat where it is emptied into the sorting box. One man hauls the pot by keeping a strain on the line from the power block while the other man fills a bait can and sorts

the previous catch. After the pot is aboard, the catch is removed and the can of old bait is exchanged for a fresh one. Legal-sized crabs are put in the circulating seawater tank and the rest of the catch, which may include fish, octopus, and small king crabs, is returned to the sea. The freshly baited pot is pushed overboard about a boat length before the next buoy. The boat remains underway during the entire picking and setting operation, maintaining a speed of about 2 knots. Because skippers usually work their strings by heading into the prevailing wind, they must run to the opposite end of the next string before picking begins again. This break gives the crew a chance to sort the previous catch, fill bait containers, and rest before hauling and setting the next string of pots.

Processing

Dungeness crabs are cooked and processed in two ways. The first and most common method is to butcher and clean the live crab, divide it into two sections (halves), and cook the sections in boiling salt water for 12 to 15 min. In the butchering, the carapace, gills, and internal organs are all removed. Each section includes a cheliped, four walking legs, and the "shoulders" –that part of the meat and shell located at the base of the legs beneath the carapace. For crabs that are sold as sections, the recovery of meat and shell is about 50% of the live weight. The cooked sections are frozen, glazed, packed, and shipped to the Seattle, Wash., area where they are thawed and the meat picked from the shell for canning. The yield of picked crab meat is 22 to 25% of the live weight.

The second method of processing entails selecting the largest and best-appearing crabs and cooking them whole for 25 to 28 min. They are then cooled; the shells are cleaned of barnacles and other marine growth on a buffing machine; and the crabs are packaged one to a paper bag for shipping and distribution for the whole crab market, usually in Seattle, San Francisco, or Los Angeles.

Recently, a market has developed for live crabs, which are shipped by air to Hawaii and other distant points (Figure 6).

RESEARCH IN ALASKA

The Alaska Department of Fish and Game began a detailed study of the Dungeness crab in the Petersburg area of southeastern Alaska in 1963. This study has been directed toward identifying geographic stocks, learning the growth and mortality rates, and estimating the

Figure 6.—Live Dungeness crabs are being prepared in a processing plant in Homer, Alaska, for air shipment to Hawaii. Less than 12 hr will lapse from the time the cover is put on this carton in Homer until these crabs are placed in a wholesaler's live tank in Honolulu.

size of the populations. Research has also been conducted by both the Alaska Department of Fish and Game and the National Marine Fisheries Service on the effects that log rafting has on the habitat of Dungeness crabs in the shallow waters of bays and estuaries in southeastern Alaska.

Perhaps the greatest threat to Dungeness crab production is the pollution that accompanies thoughtless and uncontrolled development of other resources. Future development of Alaska timber, oil, and other natural resources must include comprehensive programs of pollution abatement and control if a balanced utilization of resources is to be achieved.

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This is the sixth in a series of publications that describes the fishery resources of Alaska.
The other publications and the species described are:

U.S. Fish and Wildlife Service Fishery Leaflet 619—The Pink Salmon
U.S. Fish and Wildlife Service Fishery Leaflet 631—The Shrimps
U.S. Fish and Wildlife Service Fishery Leaflet 632—The Chum Salmon
NOAA, NMFS, Fishery Leaflet 636—The Sockeye Salmon
NOAA, NMFS, Fishery Facts—2—The Pacific Herring

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